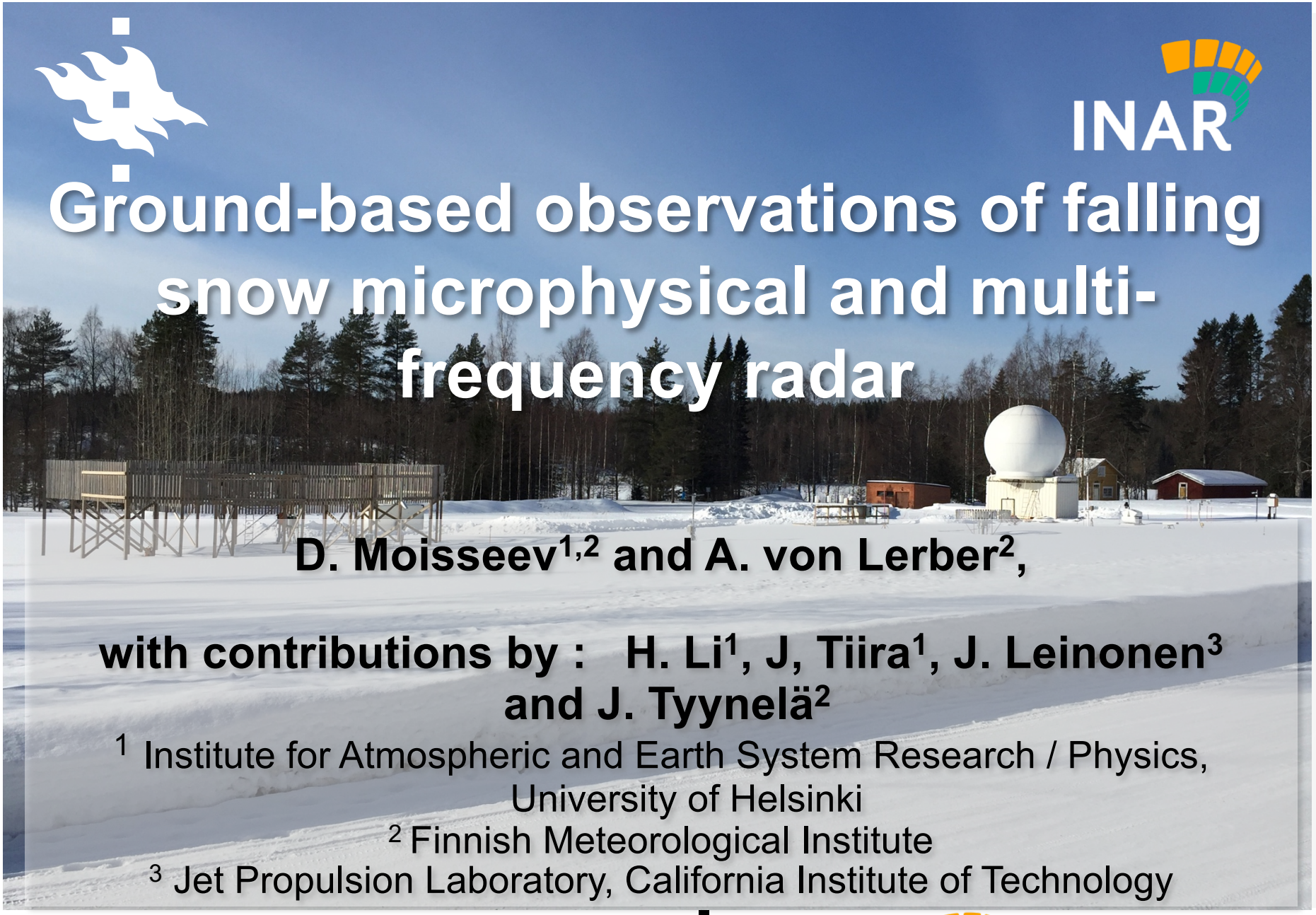


Ground-based observations of falling snow microphysical and multi-frequency radar

D. Moisseev[1,2] and A. von Lerber[2],

with contributions by : H. Li[1], J, Tiira[1], J. Leinonen[3] and J. Tyynelä[2]

[1] Institute for Atmospheric and Earth System Research / Physics, University of Helsinki

[2] Finnish Meteorological Institute

[3] Jet Propulsion Laboratory, California Institute of Technology

Measurement site

UH Hyytiälä Station
(61.84 N , 24.29 E)

- EU ACTRIS Cloud profiling station
- Extensive precipitation measurements since 2014

FMI Ikaalinen weather radar
(61.77 N, 23.08 E)

C-band radar

MWR

2014

2016

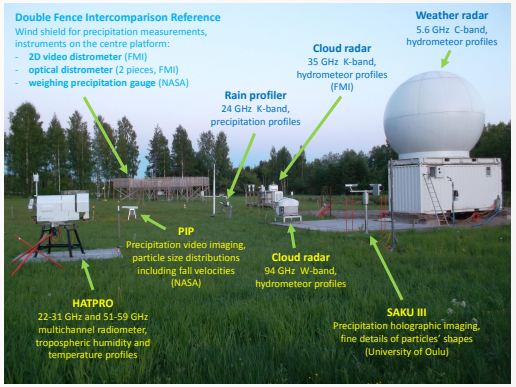
2017

2018

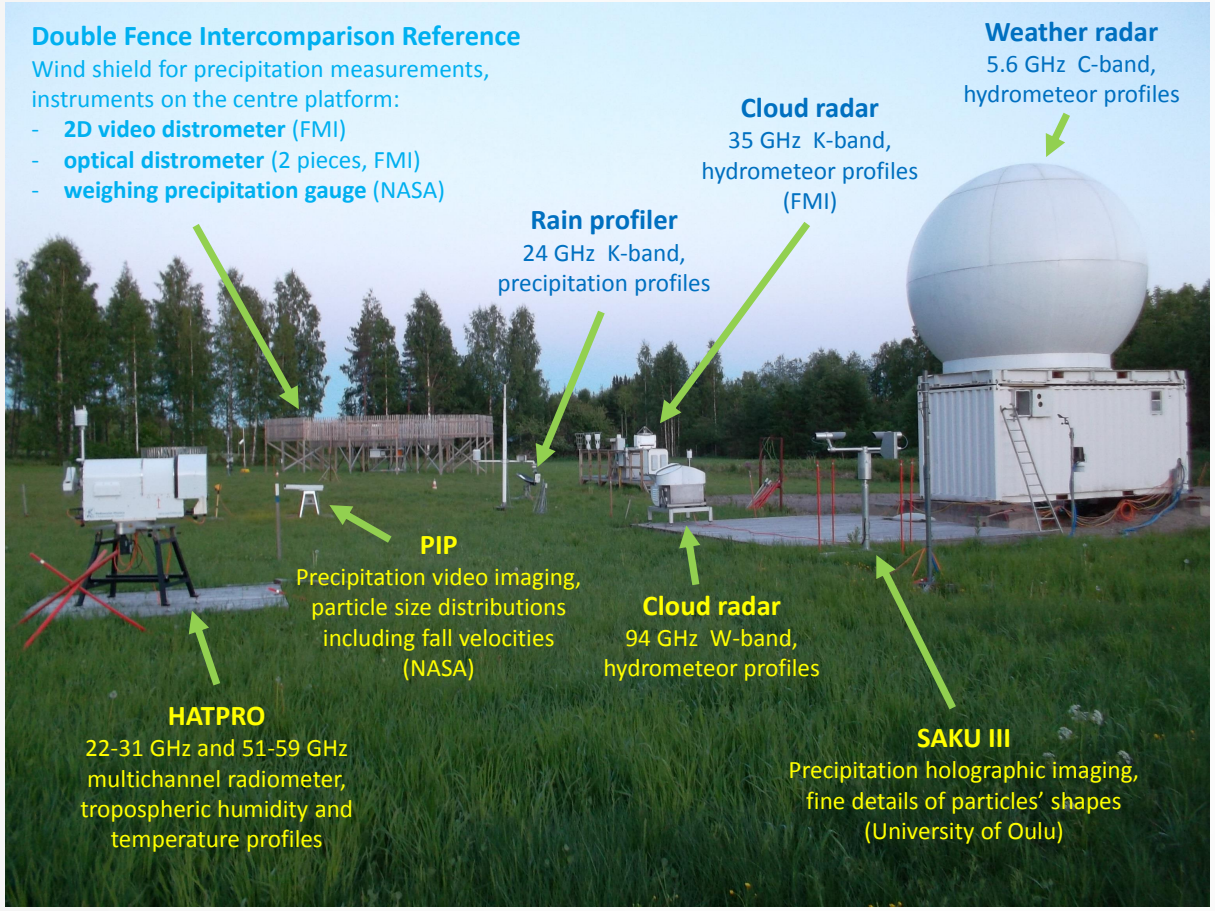
Transition to EU research infrastructure

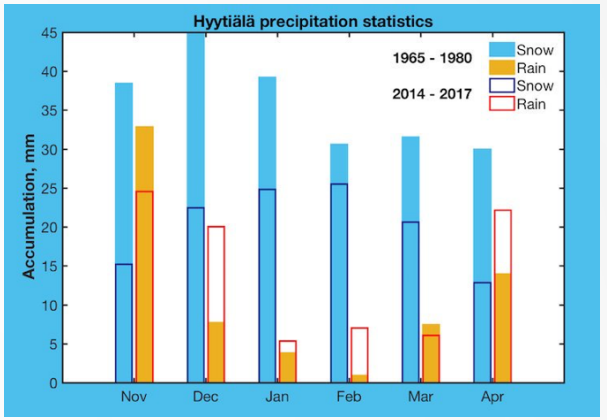
BAECC
DOE AMF2 &
NASA GPM GV

W-band Radar



UH HYYTIÄLÄ RESEARCH STATION

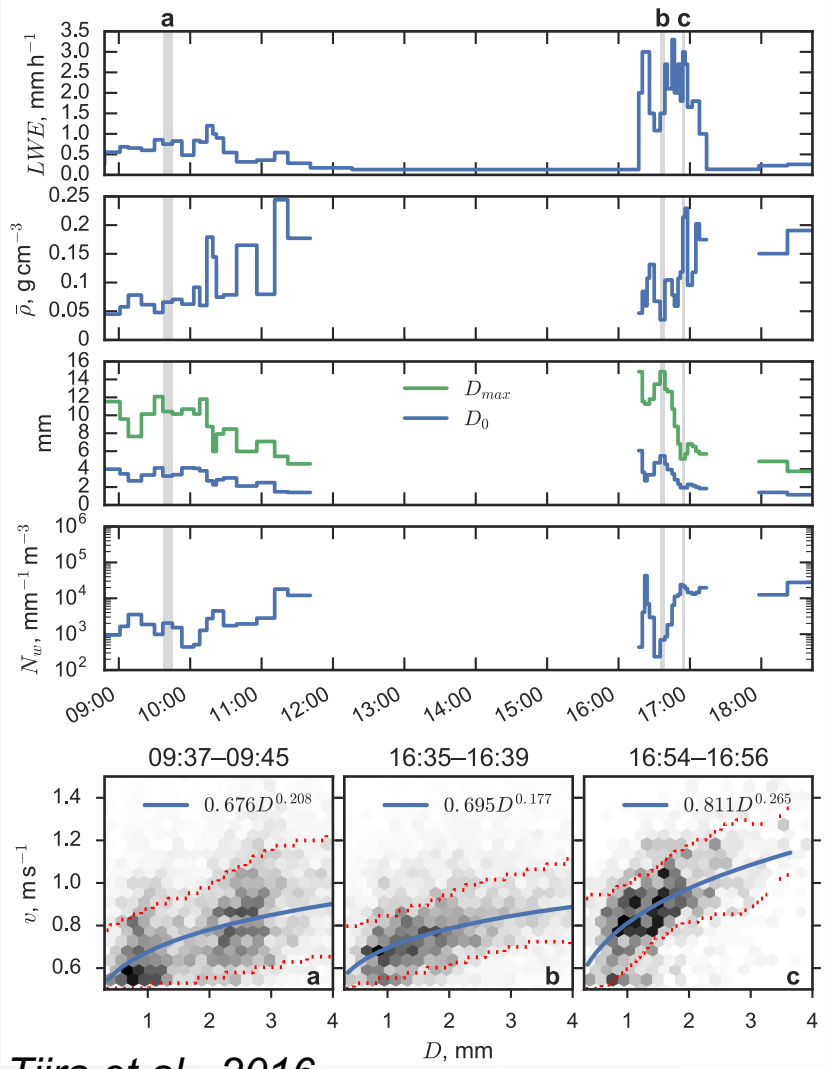




Continuous snow microphysical and multi-frequency radar observations allows to test different particle scattering models.

SNOWFALL MEASUREMENTS

18.03.2015

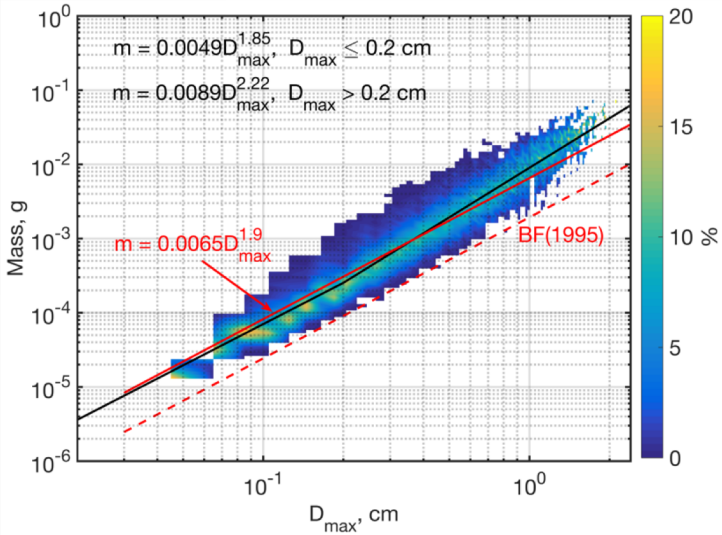


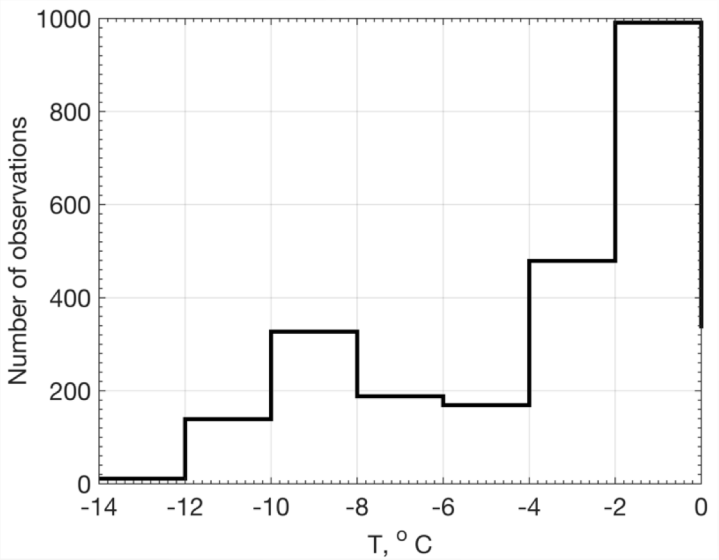
Tiira et al., 2016

- PSD, v(D) – PIP, 2DVD
- Precipitation rate – 2 weighing gauges inside and outside of the DFIR
- 2x 3D anemometers at the heights of instrument sampling volumes
- Snowflake m(D) are retrieved from v(D) following

(Mitchell and Heymsfield (2005); Heymsfield and Westbrook (2010))

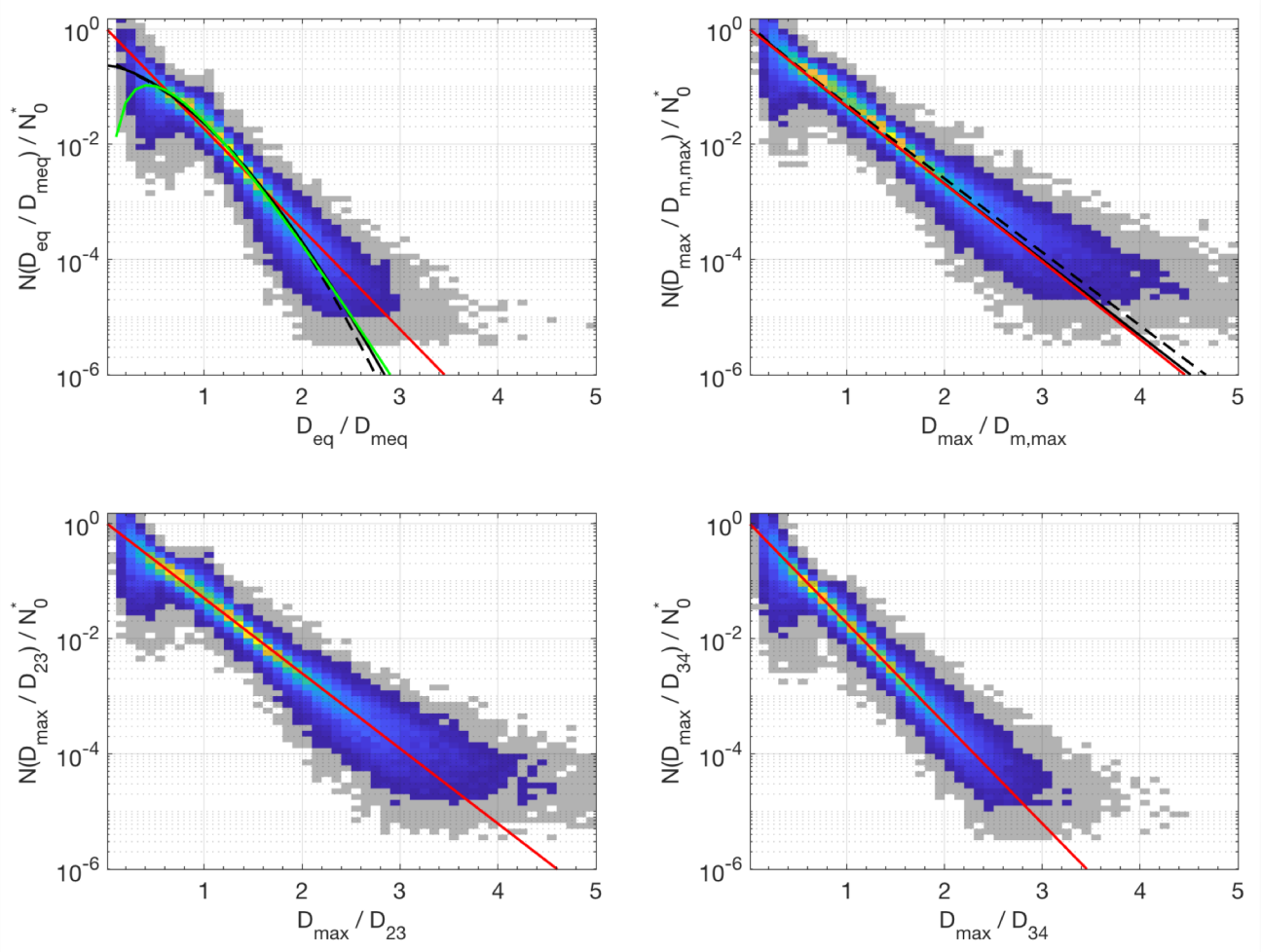
RETRIEVED ICE PARTICLE MASSES



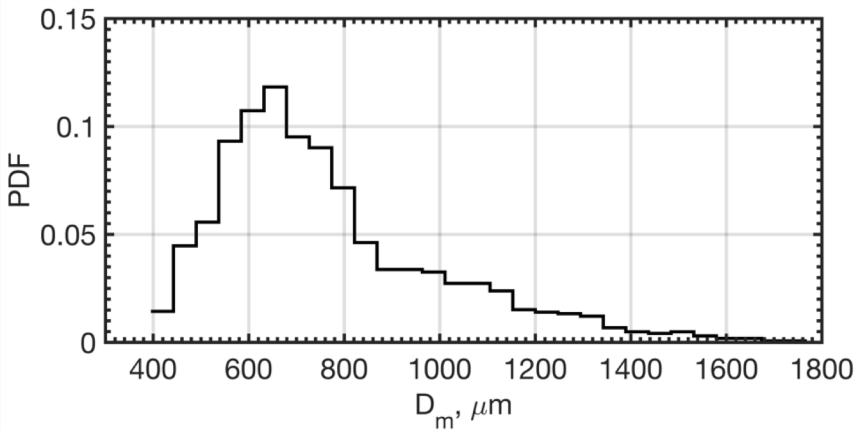


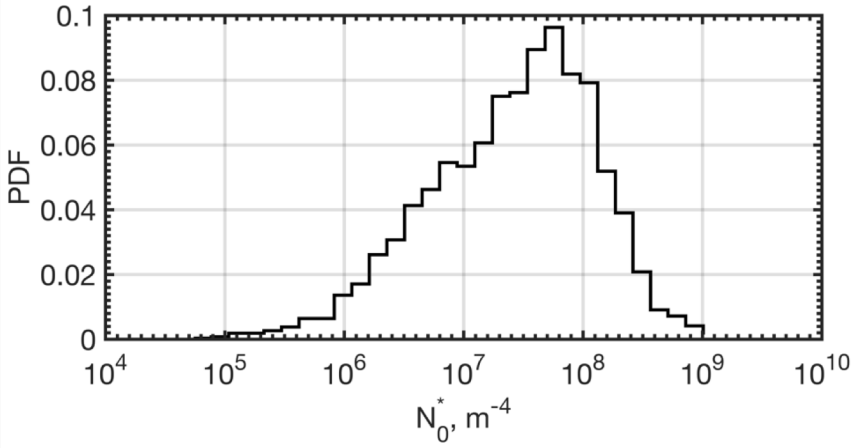
- Snowflakes are about 3 times heavier than Brown and Francis
- Indicates more riming growth
- Which is probably caused by stronger surface coupling and warmer temperatures

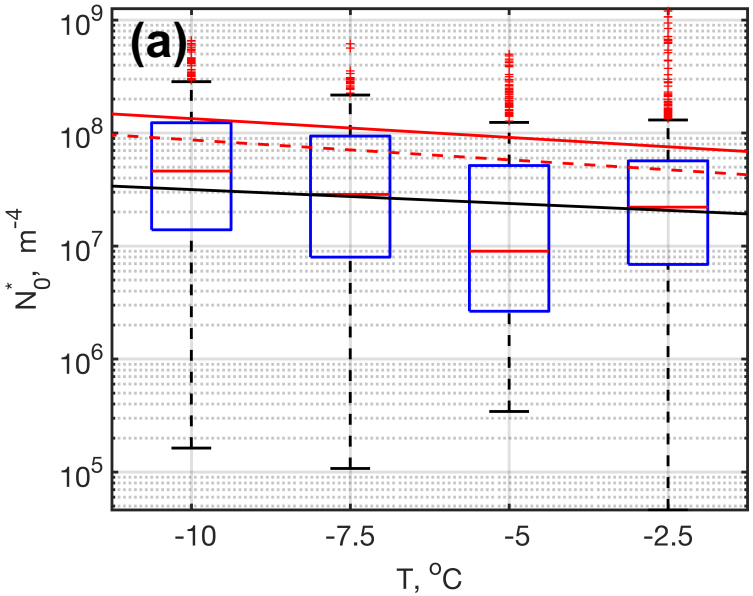
NORMALIZED PSD IN FALLING SNOW

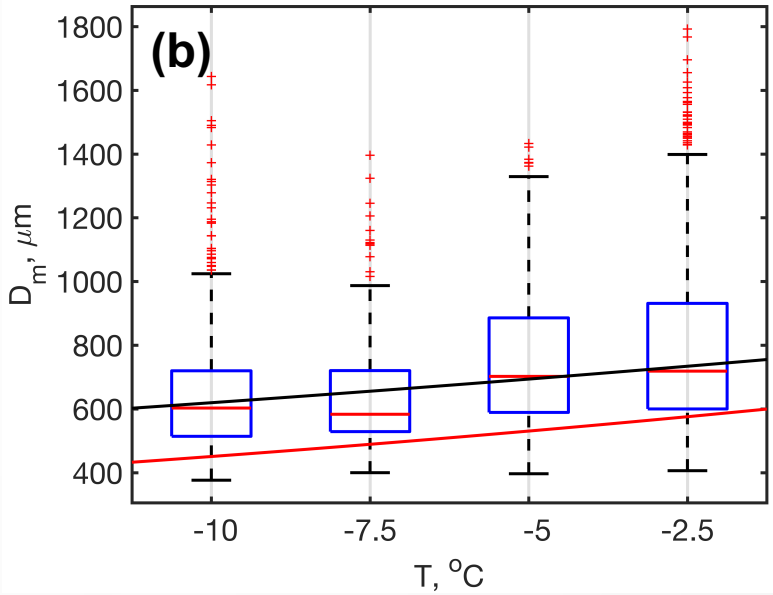


- Normalized PSD using different D definitions and D normalizations
- D_{eq} is similar to Delanoe et al., 2014
- The normalized PSD shapes are similar to those reported in literature



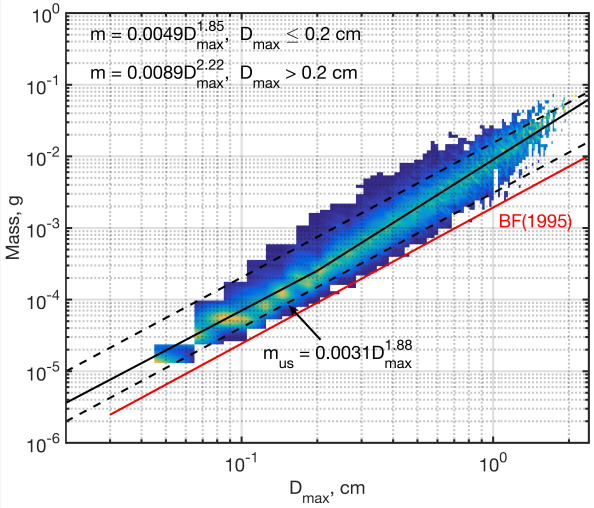




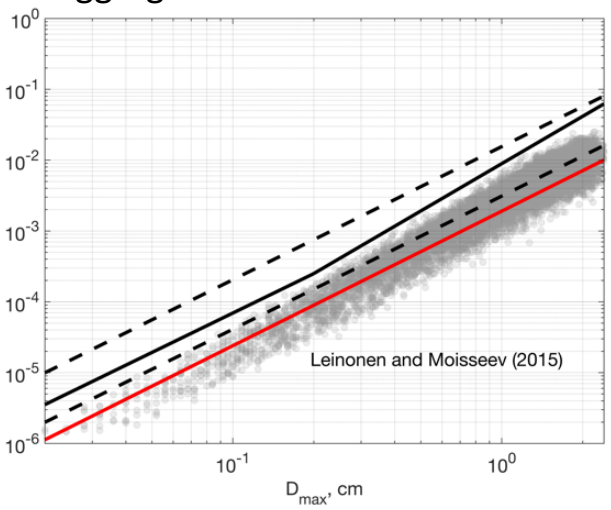


- PSD parameter distributions and their dependence on T are different from *Delanoe et al., 2014*
- But the difference can be explained by heavier particles

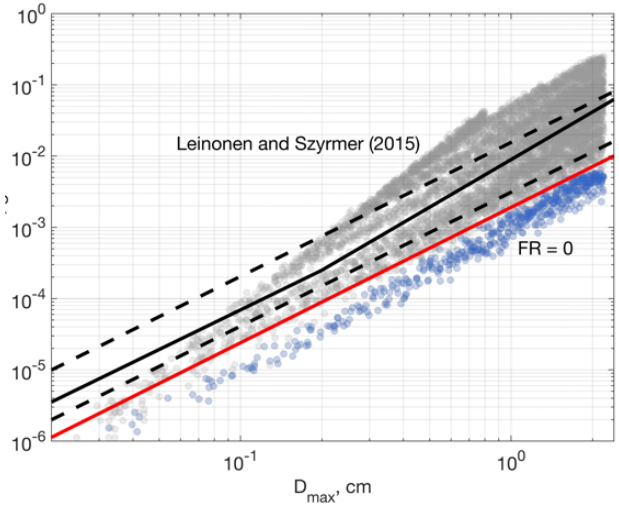
Observed snowflake masses



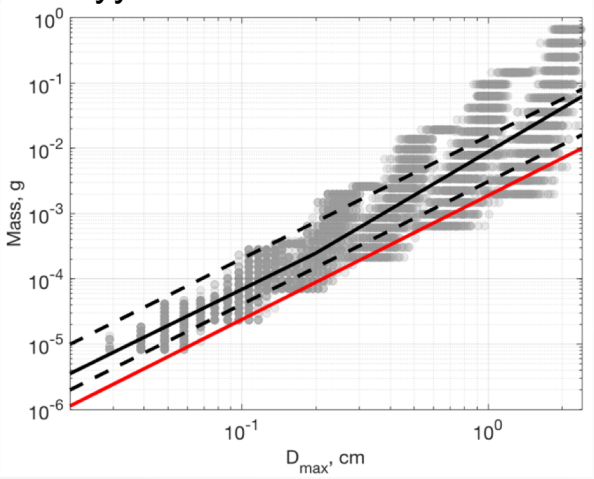
Aggregates LM2015



Rimed snowflakes LS2015



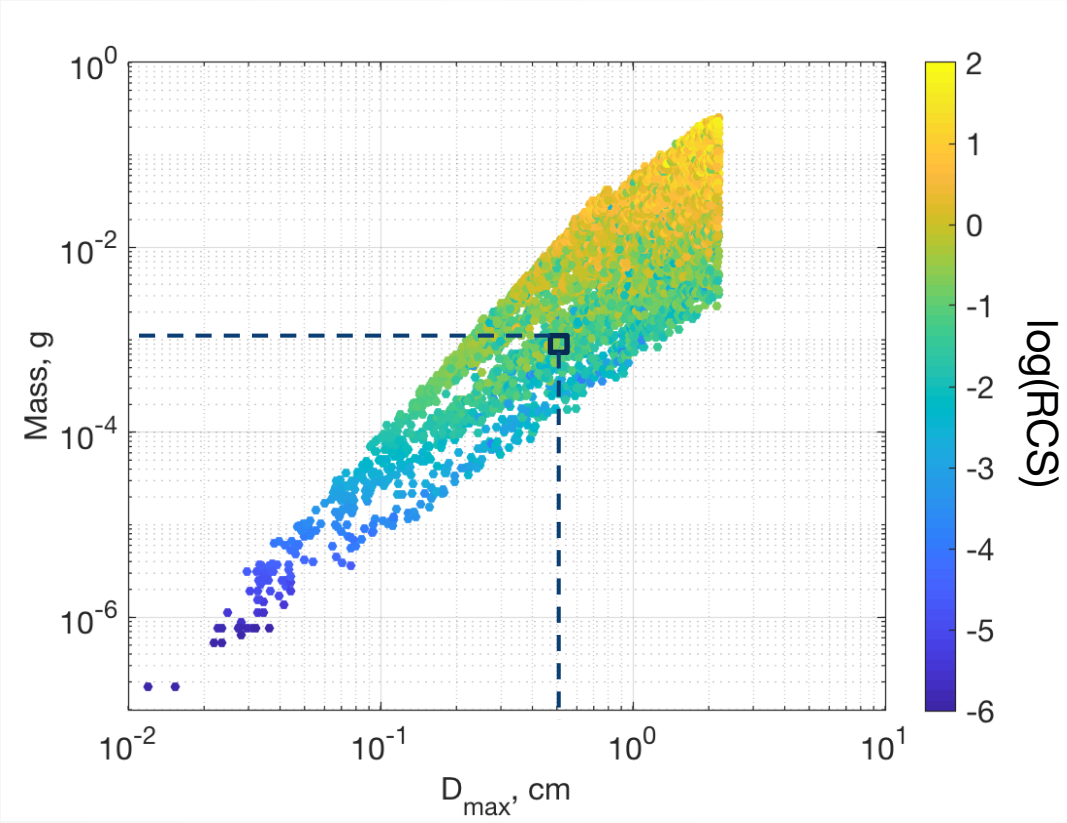
Tyynelä fractals



Observed snowflake masses and properties of three different particle models.

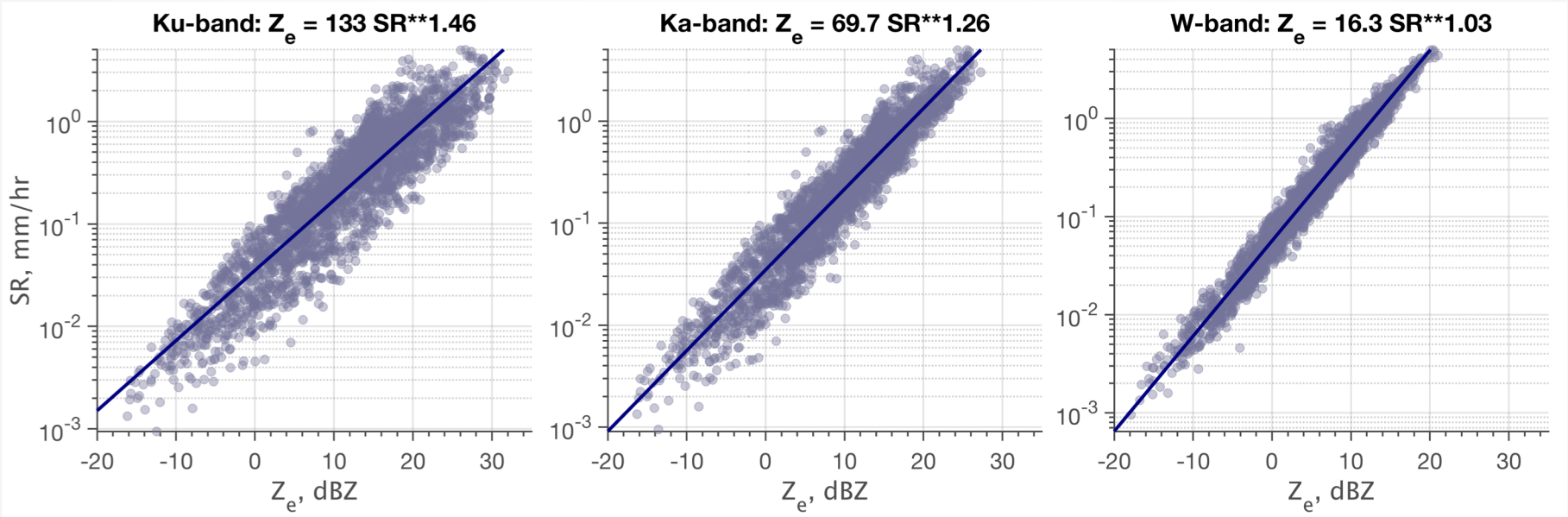
The fractal model was designed to fit our observations, while the other two models are generated by mimicking physical processes.

RCS ESTIMATION FROM SCATTERING DATABASE



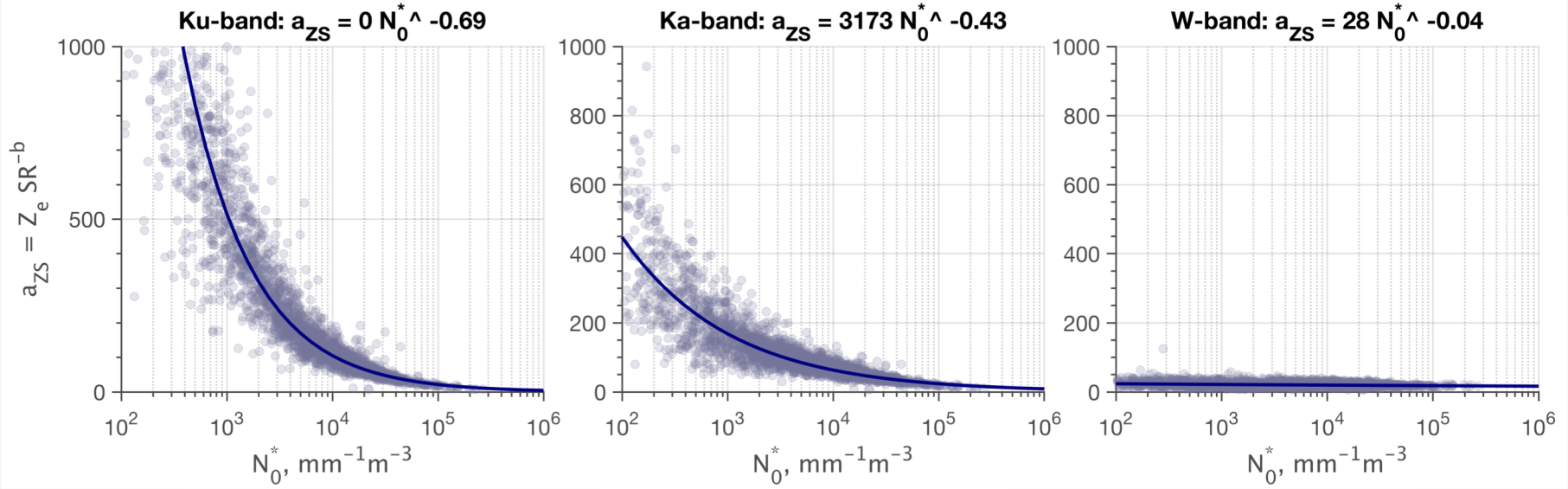
- Using retrieved *m* and D_{max} particle *RCS* is selected from a scattering database
- For this, the nearest neighbor interpolation is used
- It should be noted that both *m* and D_{max} should be used

AVERAGE Z-S RELATIONS AT DIFFERENT FREQUENCIES

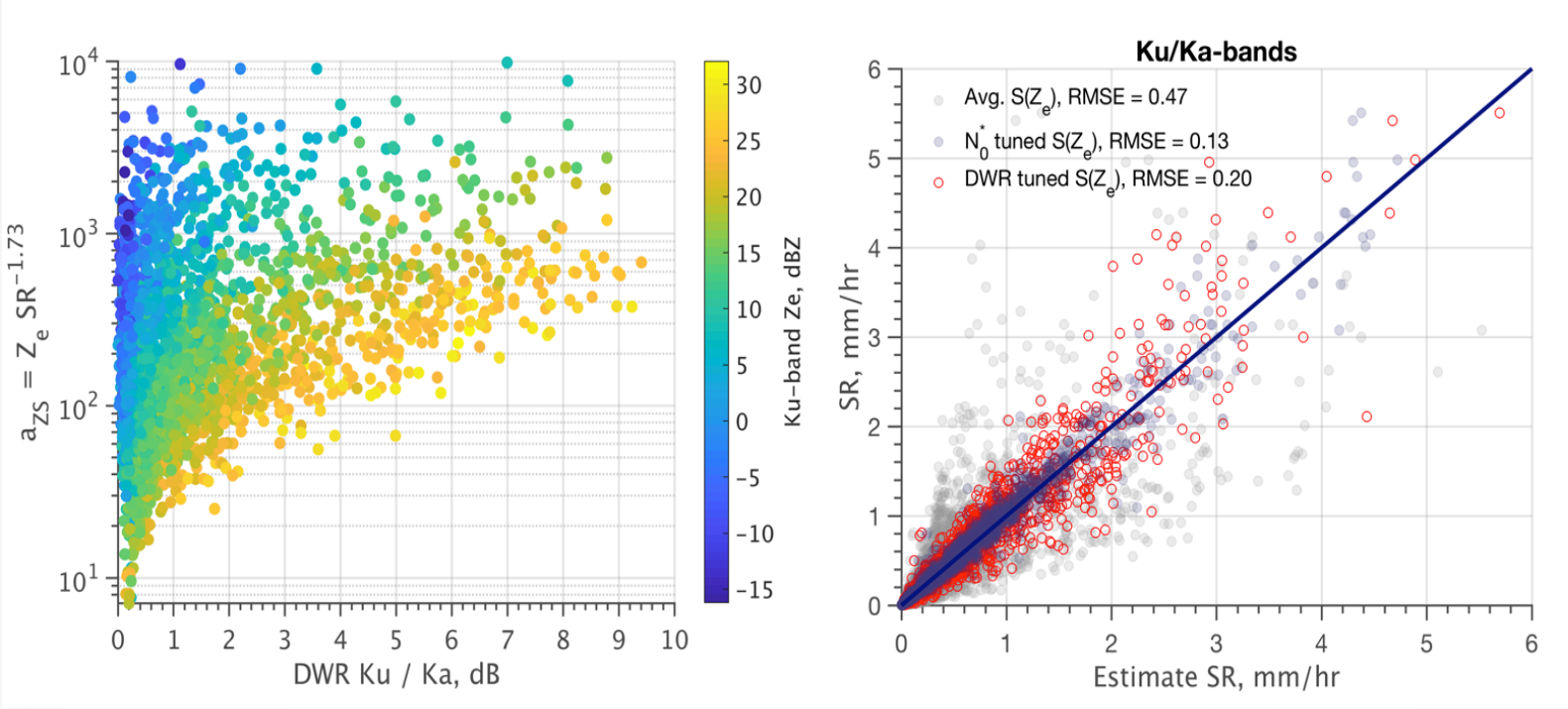


- Relations are computed using m(D), PSD, v(D) and DDA single scattering RCS
- Higher the radar frequency smaller is the spread
- How does it translate to snowfall rate estimate errors?

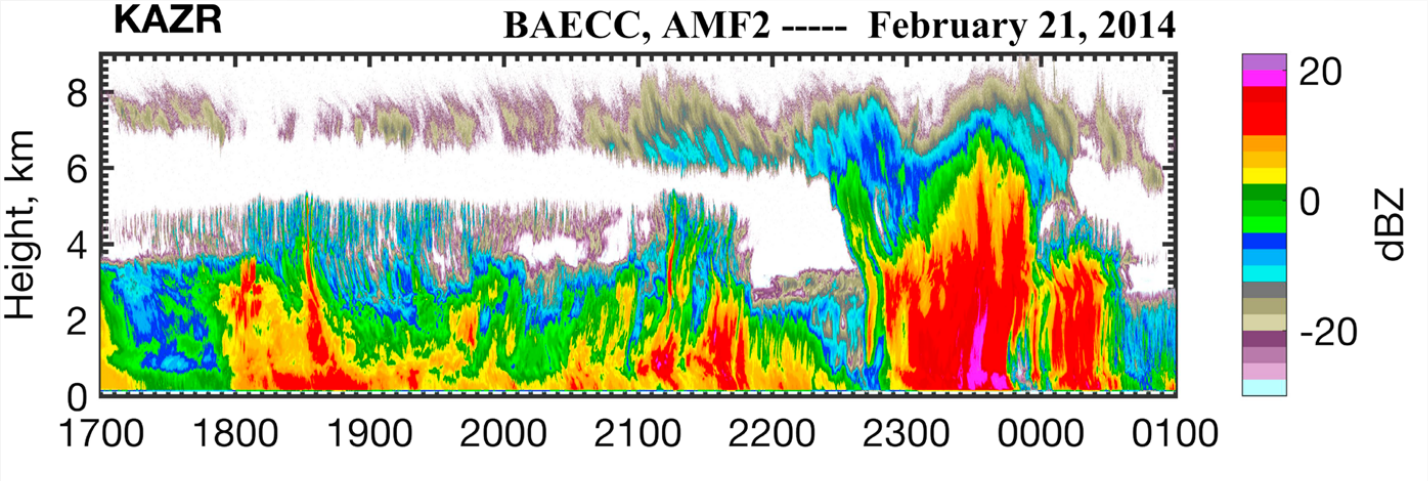
INSTANTANEOUS Z-S RELATIONS

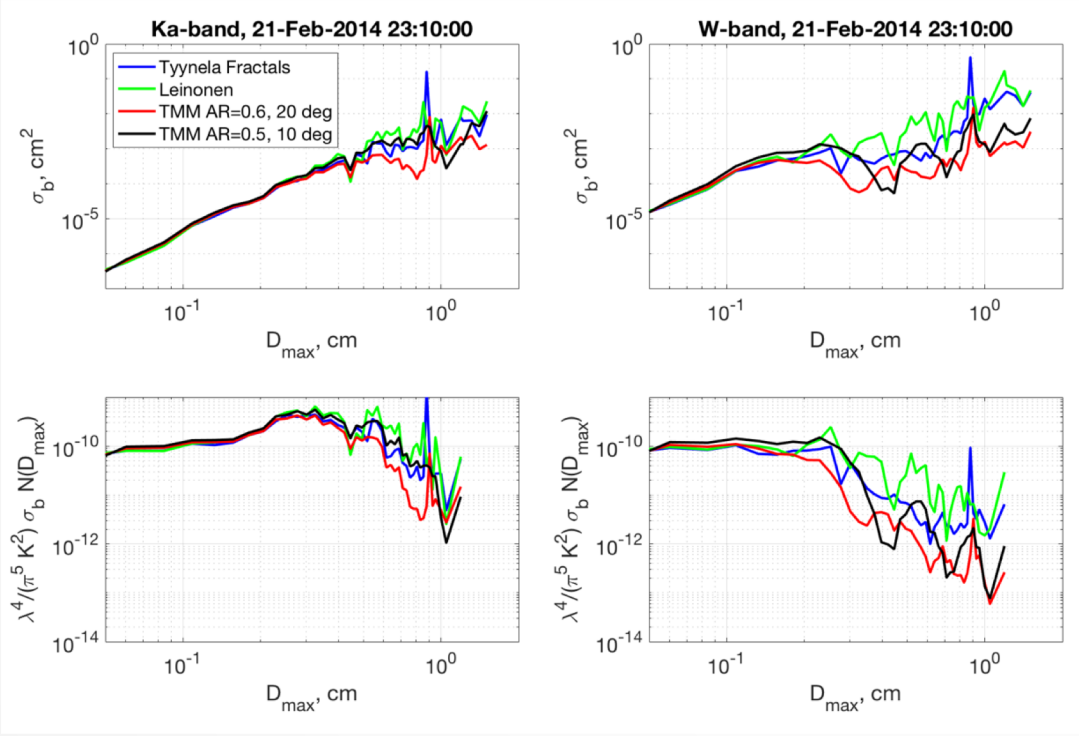


- The exponents of the relations are computed by minimizing RMSE in the estimated snowfall rate. For Ku: b = 1.76, Ka: b=1.26, W: b=1.07



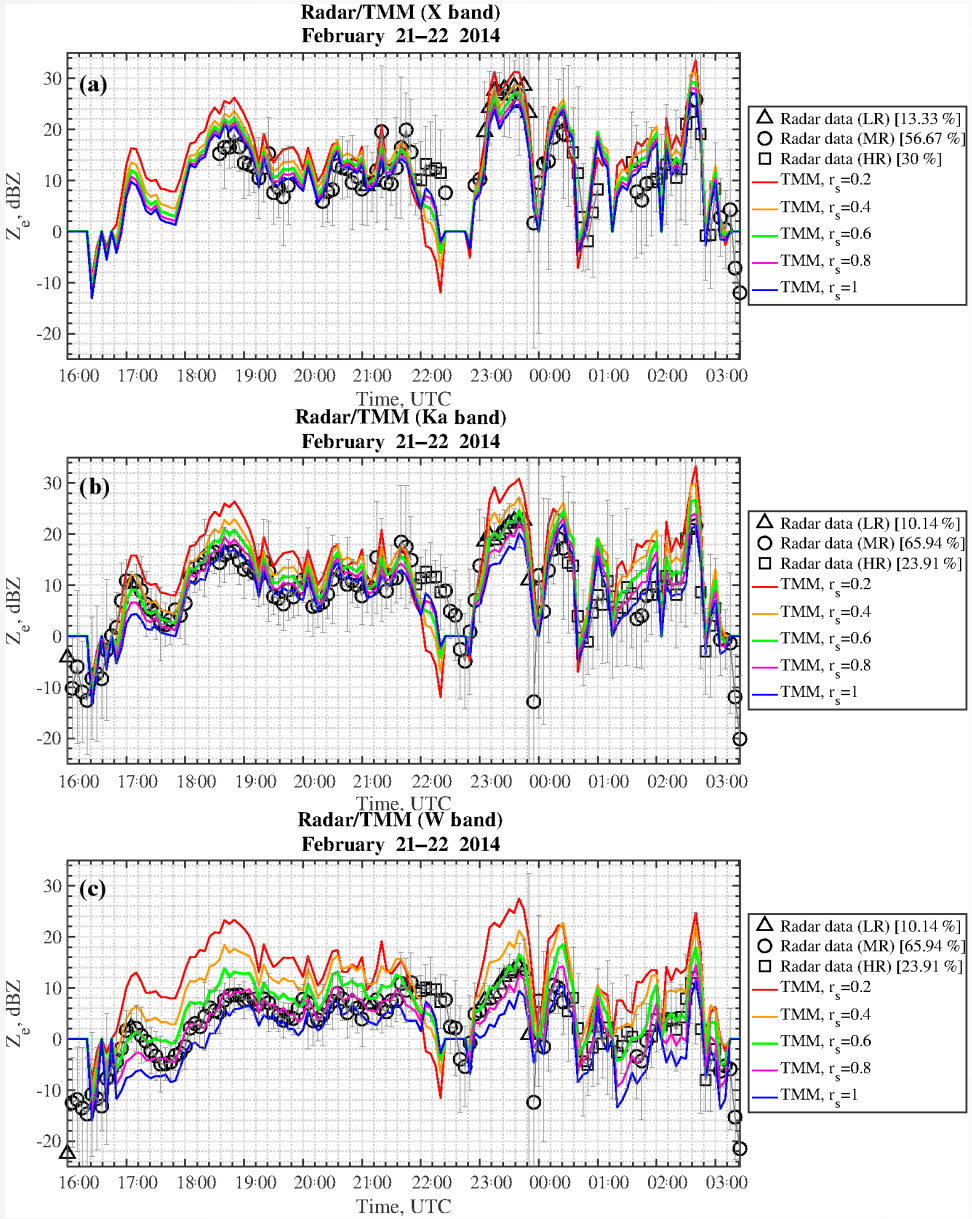
- SR retrieval using Ku and Ka observations (for more info see P127 (GCPEx) and P215)





Comparison of RCS models

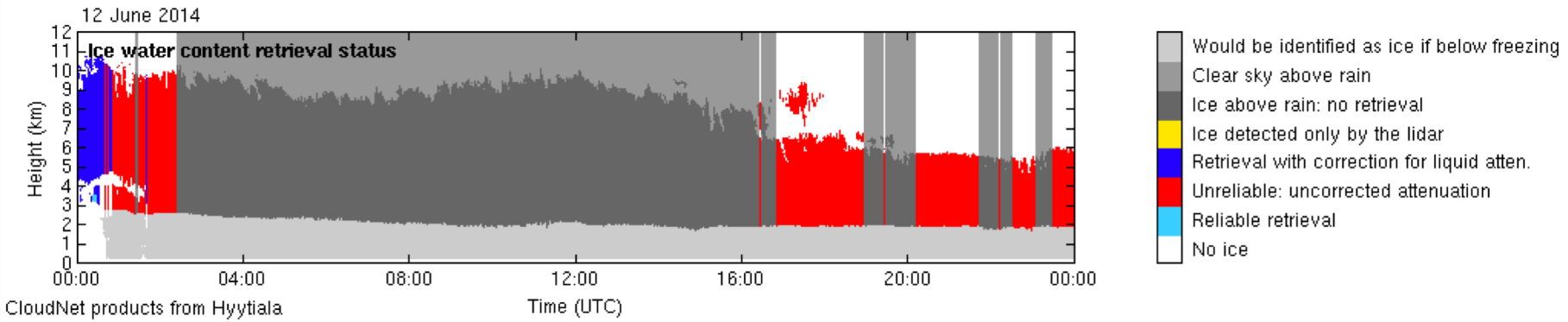
- DDA computations of different complex particle models show similar results
- T-matrix with smaller axis ratios and narrow canting angle distributions agree better with DDA



- Comparison of measured and forward simulated Ze at X, Ka and W
- The soft-spheroid particle model performs reasonably well, but has a tendency of requiring different aspect ratio at different frequencies

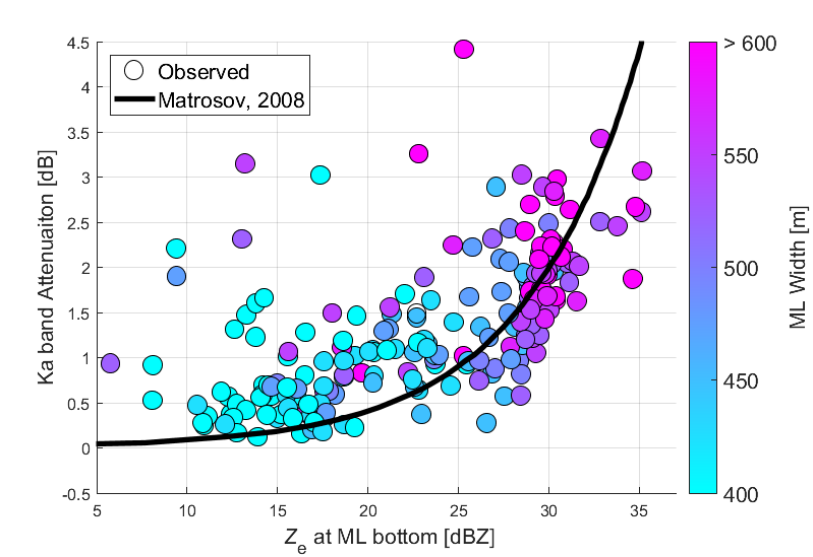
Falconi et al., 2018

CHALLENGE / ALGORITHM DEVELOPMENT: ICE RETRIEVALS DURING RAIN

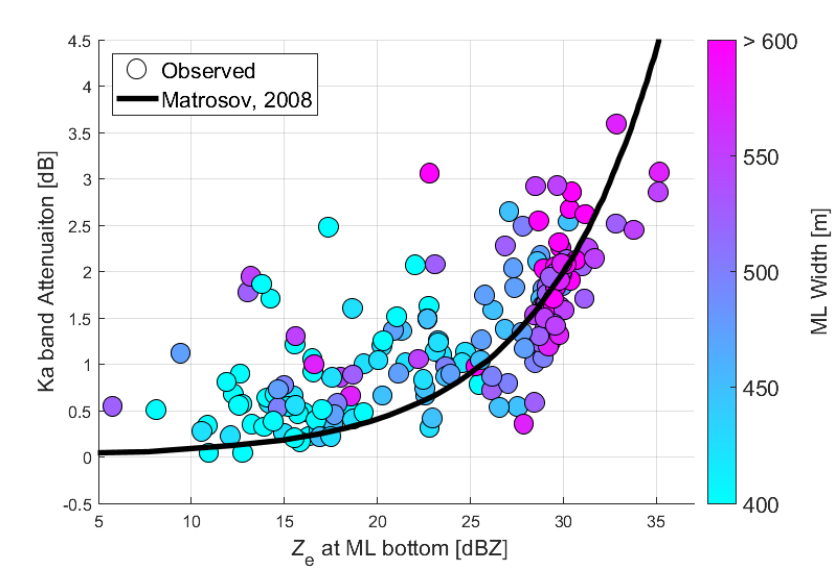


- Melting layer (+ radome and rain) attenuation correction is needed
- Multi-frequency spectra observations show a promise in mitigating this challenge

CHALLENGE / ALGORITHM DEVELOPMENT: ICE RETRIEVALS DURING RAIN



Doppler spectra in rain and cloud top



Doppler spectra in rain and ice

- Using spectral dual-wavelength ratio in rain and comparing it to sDWR in snow ML attenuation is retrieved.
- It is compared to ML attenuation estimated by matching X, Ka band observations at ice cloud top

(Li and Moisseev, 2018; in preparation)

SUMMARY

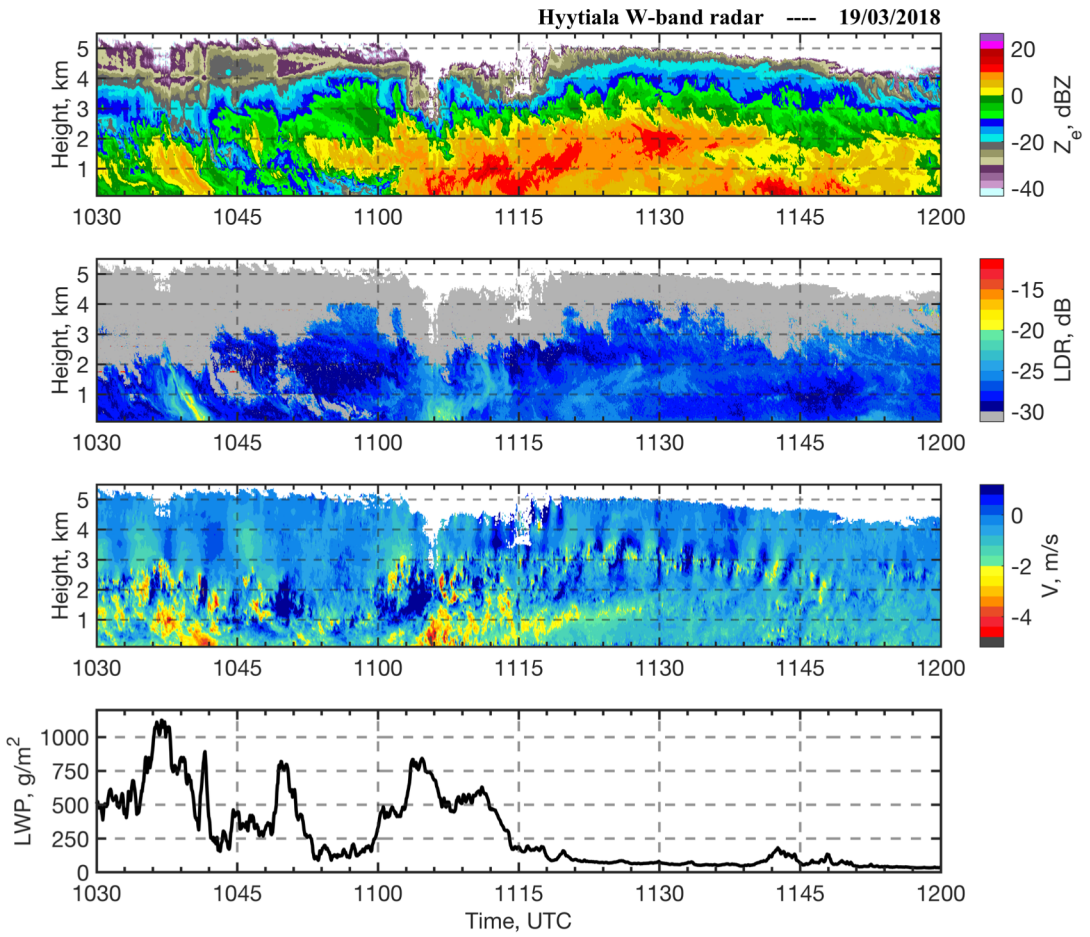
- Continuous observations of snow microphysics and multi-frequency radar observations are being collected at our measurement site
  - Used to test scattering models
  - Retrieval methods
- Uncertainty in Ze-S is frequency dependent, but can be reduced by using DWR

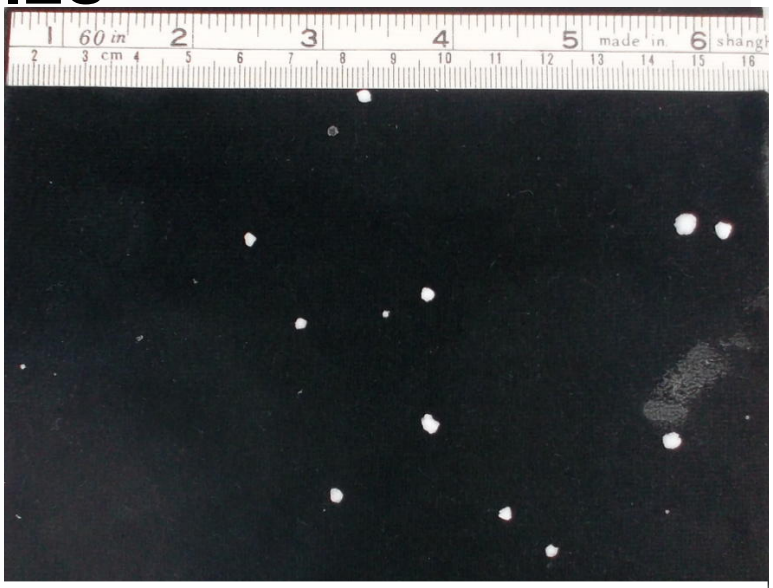
FUTURE PLANS

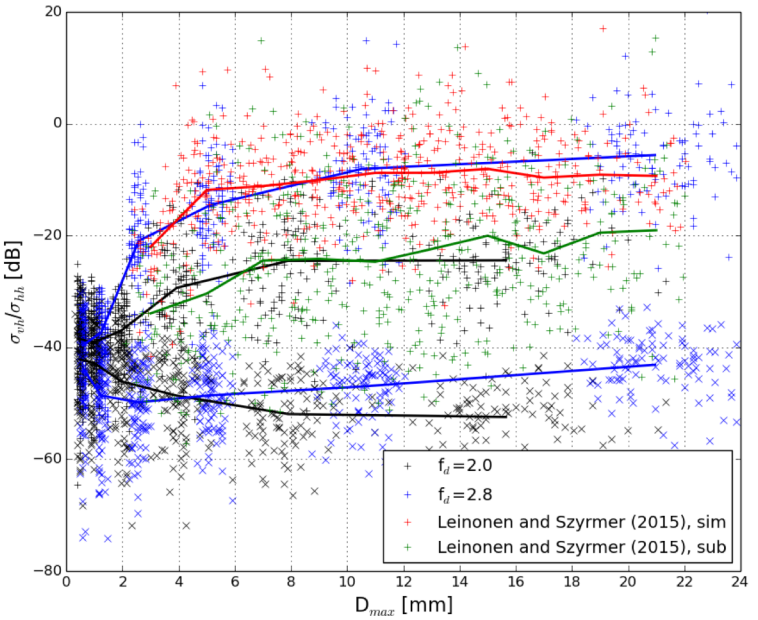
- Extending the analysis to the data from Canada CARE site (D. Hudak)
- Not mentioned in the talk: IKA radar observation combined with our m(D), PSD are used to generate gridded product for GPM GV

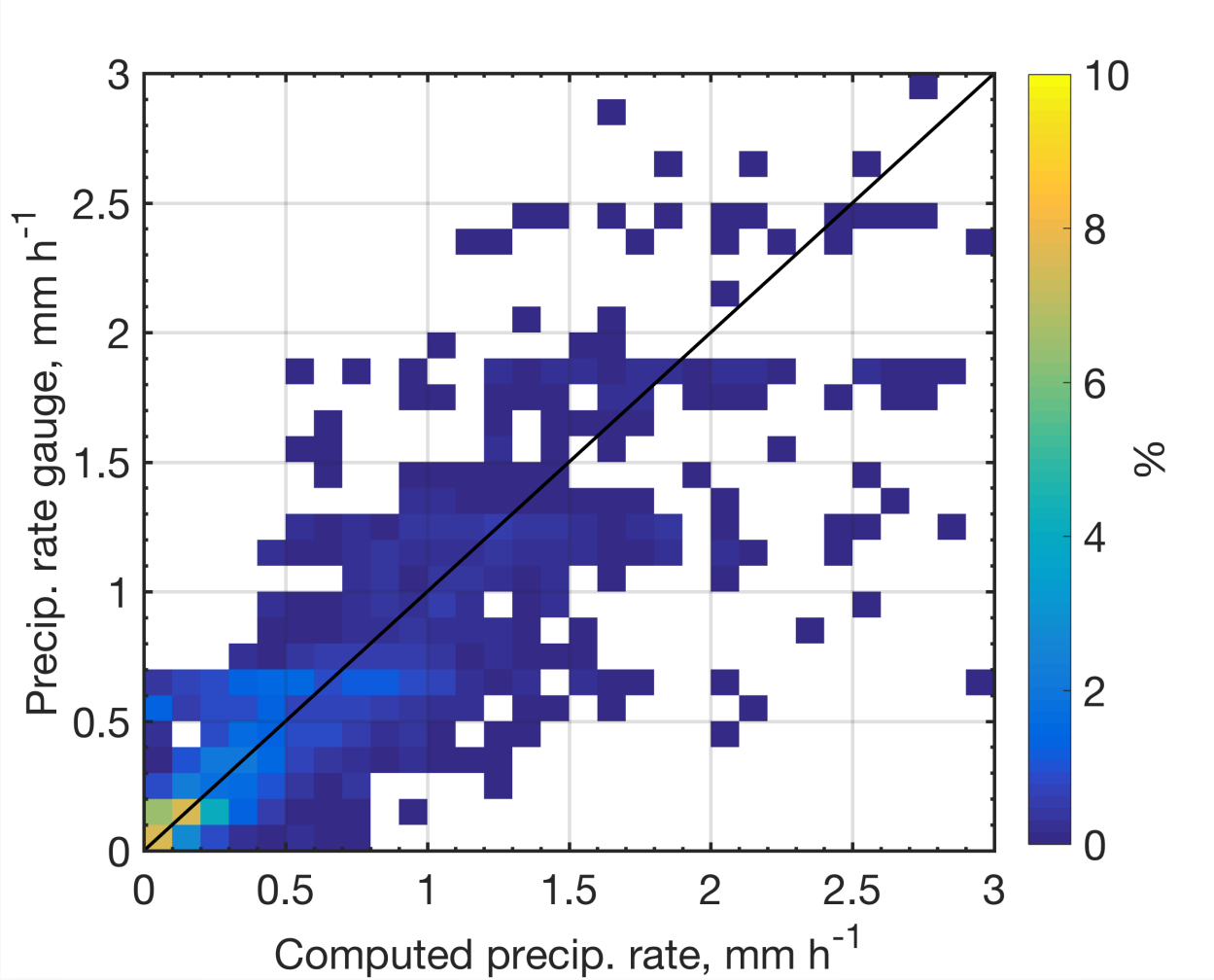
Please visit poster 215 for more information

GRAUPEL SCATTERING PROPERTIES









Estimated and measured snowfall rates